Molecular diversity and evolution of the nervous system

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ABSTRACT

In this talk I will present an overview of the research interests of the Comparative Genomics lab at IMBB-FORTH, which focuses on computational biology, comparative genomics, protein and cellular evolution. Central question in the lab is the origin, diversity and evolution of neurons and the animal neural systems. Particularly the emergence of neurotransmission as a signal transduction mechanism is key to understand the evolution of the system. It remains unclear, however, when the different molecular systems first occurred and how they were selected for in animal evolution. Current evidence indicates that diverse neurotransmitters may be found in non-bilaterian animals and even non-animal organisms. However, the physiological role in these species is elusive, and recent phylogenetic analyses have suggested that, at least the monoaminergic signalling machinery is specific to bilateria. I will present direct evidence for the pre-bilaterian origin of biogenic amine neurotransmission. We have traced the evolution of signalling molecules such as acetylcholine, serotonin, dopamine, adrenaline and trace amines, using a combination of computational and experimental approaches, including molecular phylogenies, structural modelling, targeted metabolomics and immunochemistry. The phylogenetic analysis of G-protein coupled receptors, and the analysis of single-cell gene expression patterns of the hetero-pentameric nicotinic channel subunits in different animals demonstrate that cholinergic interneuronal and neuromuscular signalling were already in place in the common ancestor and vertebrates, insects, jellyfishes and corals. I argue that biogenic amines first evolved from promiscuous synthesis pathways and transport machinery in a non-neural context, whereas specific pathways then emerged via gene duplications in Bilateria. The emerging picture suggests that a general trend from generalist to specialist machinery has driven the evolution of neurotransmission. Last, I will briefly introduce the framework and methods currently being developed in the lab two major receptor families with a central role in cognitive functions, the G protein-coupled receptors (GPCRs) and the NMDA glutamate receptors.